

PATENT ABSTRACTS OF JAPAN

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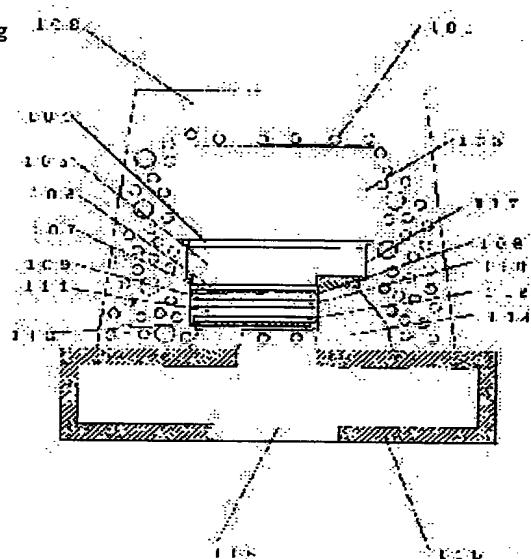
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(54) LIGHT EMITTING DEVICE**(57)Abstract:**

PROBLEM TO BE SOLVED: To provide a light emitting diode capable of eliminating color displacement and color irregularity and taking RGB emitting wavelength component as a peak value, with respect to a light emitting element having a nitride semiconductor and a light emitting diode having a fluorescent material.

SOLUTION: The light emitting device has a light emitting element with a plurality of nitride semiconductor layers different in In concentration in its well layer, and a fluorescent material emitting a longer wavelength than the light emitting element on receipt of light from the light emitting element.

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CLAIMS

[Claim(s)]

[Claim 1] Luminescence equipment with which a well layer is characterized by having the light emitting device which has two or more nitride semiconductor layers from which In concentration differs, and the fluorescent substance which emits the fluorescence of long wavelength rather than it in response to the light from this light emitting device.

[Claim 2] The fluorescence which the aforementioned fluorescent substance emits while the aforementioned light emitting device has the nitride semiconductor layer in which monochromatic peak wavelength including a blue wavelength region can emit light, and the nitride semiconductor layer in which monochromatic peak wavelength including a green wavelength region can emit light is luminescence equipment with which a white system including a red wavelength region according to claim 1 can emit light.

[Claim 3] The aforementioned fluorescent substance is luminescence equipment according to claim 2 mainly excited by the blue peak wavelength to which a light emitting device emits light.

[Claim 4] The aforementioned fluorescent substance is luminescence equipment according to claim 1 to 3 which is one sort chosen from nitrogen content CaO-aluminum₂O₃-SiO₂ activated by Y₂O₃.5/3aluminum₂O₃ activated by Ce, Eu, and/or Cr.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention relates to the luminescence equipment which there are few color gaps and irregular colors and can be especially taken out by the RGB luminescence wavelength component as a peak, respectively with respect to the luminescence equipment using the light emitting device which has a nitride semiconductor, and the fluorescent substance which absorbs the light from a light emitting device, carries out wavelength conversion and emits fluorescence.

[0002]

[Description of the Prior Art] As the blue glow from the light emitting device using the nitride system compound semiconductor ($In_xGa_{1-x}Al_1-yN$, $0 \leq x \leq 1$, $0 \leq y \leq 1$) to which blue can emit light in high brightness, and this light emitting device was absorbed and such color mixture light showed to drawing 3 combining the fluorescent substance with which yellow light can emit light, the light emitting diode to which a white system can emit light was developed. The Light Emitting Diode chip (303) to which white light emitting diode was electrically connected by the lead electrode (315) and the conductive wire (304) of a couple is arranged in the mold cavity of a case (316). The mold cavity is filled up with resin (301) which the fluorescent substance (302) contained. Since this light emitting diode has a reliable property by the small light weight one of light emitting diode, and the low power, it is spreading quickly as the back light of liquid crystal equipment, the light source for mount, etc.

[0003] The emission spectrum of such light emitting diode is shown in drawing 4. Although a comparatively broadcloth emission spectrum is emitted from light emitting diode compared with the blue glow from a light emitting device with monochromatic peak wavelength, and a light emitting device as shown in drawing 4, color mixture light with yellow light with few wavelength regions which emit light in redness from a fluorescent substance is emitted. Therefore, color rendering properties become low. the white light from light emitting diode — a coloring filter — using — RGB (red and green — blue) — when it divides into each wavelength region, there are few red components, and it is in the inclination for color production nature to become bad. In order to prevent these, it is also solvable by adding the fluorescent substance or light emitting device which emits light in red.

[0004] However, while the new process of all increases, it is very difficult to make a color adjust. Therefore, an irregular color and color gap will arise depending on the case, and the yield will fall. When using white light emitting diode as the back light light source of liquid crystal etc. especially, the light from light emitting diode is divided into the component of RGB (red, green, blue) which is the three primary colors of light with a coloring filter. The component of each RGB can be indicated by multicolor by controlling permeability by liquid crystal. Therefore, if the component of RGB cannot be taken out to high brightness, the brighter high multicolor display of color rendering properties is difficult.

[0005]

[Problem(s) to be Solved by the Invention] Therefore, this invention is comparatively easy composition and the luminescence component of RGB with more few color gaps and irregular colors is to offer the white light emitting diode which can emit light in high brightness. In the present when a high brightness low power is called for more, in the composition of the above-mentioned light emitting diode, it is not enough, and the further improvement is called for.

[0006]

[Means for Solving the Problem] this invention is luminescence equipment which has the light emitting device in which a well layer has two or more nitride semiconductor layers from which concentration differs, and the fluorescent substance which emits the fluorescence of long wavelength rather than it in response to the light from a light emitting device. The very high light emitting diode of color rendering properties in which color mixture luminescence in high brightness is possible can be made to form with the sufficient yield by comparatively easy composition of such a 1 chip one terminal pair network.

[0007] While, as for the luminescence equipment of this invention according to claim 2, a light emitting device has the nitride semiconductor layer in which monochromatic peak wavelength including a blue wavelength region can emit light, and the nitride semiconductor layer in which monochromatic peak wavelength including a green wavelength region can emit light, the fluorescence which a fluorescent substance emits is luminescence equipment including a red wavelength region. The white light emitting diode which can emit light in high brightness can be made to form RGB with comparatively easy composition by this.

[0008] The luminescence equipment of this invention according to claim 3 is luminescence equipment with which a fluorescent substance is mainly excited by the monochromatic blue peak wavelength from a light emitting device. This reliability — the high fluorescent substance which can emit light in high brightness can be used.

[0009] The luminescence equipment of this invention according to claim 4 is one sort chosen from nitrogen content CaO-aluminum2O3-SiO2 activated by Y2O3.5/3aluminum2O3 by which the fluorescent substance was activated by Ce, Eu, and/or Cr. Thereby, it can consider as the luminescence equipment in which reliable color mixture luminescence in high brightness is simple and possible.

[0010]

[Embodiments of the Invention] this invention person used to find out that it can consider as the white light emitting diode

which can take out the component of RGB with sufficient balance in high brightness by comparatively easy composition by combining the nitride semiconductor light emitting device to which blue and green can emit light, and the fluorescent substance with which red can emit light.

[0011] That is, it is made possible to make the light emitting device which can emit light to ultraviolet short wavelength form by making the composition ratio of InGaN fluctuate of the light emitting device using the nitride semiconductor. This is because there is an inclination that luminance of long wavelength can be obtained according to the composition ratio by increasing In content of a barrier layer. However, the nitride semiconductor containing many In(s) will be easy to disassemble if it becomes an elevated temperature. Moreover, it is very difficult to make a nitride semiconductor layer with many crystalline good amounts of In(s) form. Therefore, although the light emitting device to which blue, green, and yellow can emit light can form what has a now comparatively good controllability that can emit light in high brightness, it is one of the reasons which the light emitting device to which the monochromatic peak wavelength containing a red component can emit light cannot form easily.

[0012] Therefore, this invention makes the nitride semiconductor with a comparatively sufficient controllability with which a blue component and a green component can emit light form as a light emitting device using multiplex quantum well structure. That is, luminescence of a color component which the mixed-crystal ratios of two or more well layers differ, and is different from each well layer, for example, a blue component, and a green component is carried out, and a synthetic light is made to take out. On the other hand, it is excited, the electromagnetic wave, for example, the blue light, to which the remaining red components were emitted from the light emitting device, and white light emitting diode is made to form using the fluorescent substance changed into the light of long wavelength rather than it.

[0013] Although the luminescence equipment of this invention is shown in drawing 1 and concrete composition is explained in full detail hereafter, not being restricted only to this cannot be overemphasized. The semiconductor of this invention can use the MOCVD method, can pour [as material gas / as TMG (trimethylgallium) gas, TMA (trimethylaluminum) gas, TMi (trimethylindium) gas, ammonia gas, and impurity gas] hydrogen gas according to a request variously as SiH₄ (silane), Cp₂Mg (magnesium cyclopentadienyl), and carrier gas, and can make a desired semiconductor film form.

[0014] The buffer layer which more specifically consists of GaN which made membranes form at low temperature on silicon on sapphire (103) (104). The n type GaN layer which is not doped or there are little n type GaN layer which is not doped or the r is little n type high impurity concentration, n type contact layer which consists of GaN of Si content in which n type electrode is formed, and n type high impurity concentration (these three n type nitride semiconductor layers are typically set to 105.) n type clad layer which was made to carry out two or more laminations of AlGaN of Si content, and the GaN of Si content, and was used suitably (non-** view). The luminous layer to which two or more set laminating of the InGaN (107) (109) as GaN (106) (108) (110) / a well layer as a barrier layer of the thickness made into quantum well structure was carried out. It comes to carry out the laminating of p type clad layer (111) to which two or more set laminating of the GaInN by which GaN/Mg by which Mg was doped was doped was carried out, and the p type contact layer (112) which consists of GaN by which Mg was doped. In this way, while exposing n type of a semiconductor wafer and p type contact layer by which the laminating was carried out by etching, the electrode (113) for n type and p types is made to form on a semiconductor wafer by the sputtering method etc., respectively. It covers with the insulating member of SiO₂ except each electrode exposed surface. Then, let each be a light emitting device by cutting a semiconductor wafer in the size of each light emitting device using a dicer or a scribe.

[0015] A characteristic thing has at least two kinds of well layers (107) (109) from which those with two or more sets and In composition ratio differ [GaN(106) (108)/InGaN(107) (109)/GaN (106) (110) which works as a luminous layer] by this invention. In composition ratio is chosen suitably possible [luminescence of the blue glow to which at least one has monochromatic peak wavelength in 490nm from 420nm especially while the]. On the other hand, In composition ratio is chosen suitably possible [luminescence of the green light to which at least one of the remaining well layers has monochromatic peak wavelength in 555nm from 495nm]. Therefore, the cyanogen whose light emitted from a light emitting device is as green a color mixture light as blue will be observed. In addition, since it is in the inclination for the luminous layer which emits light to be able to form short wavelength with sufficient crystallinity more, when making a nitride semiconductor form from on silicon on sapphire, a spinel substrate, a gallium-nitride substrate, or a SiC substrate, it is desirable to arrange the well layer which emits light in blue to a substrate side rather than the well layer which emits light in green. Moreover, if the number of laminations of a well layer is made to fluctuate in order to make the luminescence intensity of each color adjust, it can be made to adjust comparatively simply.

[0016] Next, in this invention, it is excited by the light emitted from the light emitting device, and the fluorescent substance with which the red system of long wavelength can emit light is used rather than it by it. It is higher for efficiency for a fluorescent substance to emit the fluorescence of long wavelength rather than excitation wavelength. Moreover, although there are an inorganic fluorescent substance and an organic fluorescent substance in a fluorescent substance, excitation wavelength and luminescence wavelength can bring an organic fluorescent substance close comparatively, and let it be what can be efficient and can emit light. Therefore, the blue glow from a light emitting device can be received, a fluorescent dye or not only an organic fluorescent pigment but the green light to which red can emit light can be absorbed, and the fluorescent dye and the organic fluorescent pigment to which red light can emit light can be used. By this, it can also carry out that it is easy to make a tint adjust. On the other hand, even if it approaches and prepares an inorganic fluorescent substance in a light emitting device more, it is in the inclination with sufficient reliability which can emit light over a long time.

[0017] Y₂O₃:5 / 3aluminum2 activated by Ce as such a fluorescent substance (101) — nitrogen content CaO-aluminum₂O₃-SiO₂ activated by O₃, Eu, and/or Cr is mentioned Mg₅Li₆Sb₂O₁₃:Mn, Mg₂TiO₄:Mn, Y₂O₃:Eu, Y₂O₂S:Eu, 3.5 MgO-MgF₂ and GeO₂:Mn, a perovskite system derivative, etc. can be suitably mentioned to others.

[0018] For example, nitrogen content CaO-aluminum₂O₃-SiO₂ fluorescent substance activated by Eu and/or Cr makes raw materials, such as an aluminum oxide, a yttrium oxide, a silicon nitride, and a calcium oxide, fuse and fabricate the powder which mix with rare earth raw material to the predetermined ratio in 1300 degrees C to 1900 degrees C (from 1500 degrees C to 1750 degrees C [preferably]) in the bottom of nitrogen-gas-atmosphere mold. The ball mill of the mold goods can be carried out, and a fluorescent substance can be made to form in washing, separation, dryness, and the last

through a screen. It can consider as the calcium-aluminum-Si-O-N system oxy-night RAIDO fluor scenc glass activated by Eu to which red luminescence can emit light, and/or Cr by the excitation spectrum which had a peak in 450nm by this, and the blue glow which has a peak in about 450nm.

[0019] In addition, the peak of an emission spectrum can be continuously shifted from 575nm to 690nm by fluctuating the nitrogen content of the calcium-aluminum-Si-O-N system oxy-night RAIDO fluor scenc glass activated by Eu and/or Cr. Similarly, an excitation spectrum can also be shifted continuously. Therefore, a white system can be made for the light from the gallium-nitride system compound semiconductor which contains in a luminous layer GaN by which impurities, such as Mg and Zn, were doped, and InGaN to emit light by the synthetic light of the light of about 580nm fluorescent substance. Especially, about 490nm light can also obtain luminescence ideal for combination with the light emitting device which consists of a gallium-nitride system compound semiconductor which contains in a luminous layer InGaN which can emit light in high brightness.

[0020] If it is Y2O2 S:Eu, Y2O3 and Eu2O3 will be made similarly to coprecipitate as an oxalate after the dissolution with a hydrochloric acid. This precipitate is heated at 800 to 1000 degrees C in air, and it is considered as an oxide. Furthermore sulfur, sodium carbonate, and flux are mixed, and it is put into the crucible of an alumina, it calcinates from 2 hours in 1000 to 1200 degrees C air for 3 hours, and a burned product is obtained. The fluorescent substance of Y2O2 S:Eu is obtained by grinding a burned product, washing, carrying out separation dryness and finally letting it pass to a screen. This fluorescent substance can absorb the blue glow from a light emitting device efficiently, and can emit the fluorescence of a red system. An above-mentioned fluorescent substance may be used by one kind, can mix a two-kind top and can also be used.

[0021] Into binders (102), such as an epoxy resin, silicone resin, or low melting point glass, this fluorescent substance (101) is mixed and it is considered as a slurry. The blue and green which were mentioned above make the light emitting device of multiple quantum well structure with the barrier layer which can emit light, respectively apply and harden the slurry of fluorescent substance content, and make luminescence equipment form. Or it can also use together as a die bond resin. After arranging a light emitting device and making it more specifically connect electrically on the circuit board using conductive pastes (114), such as conductive wires, such as a gold streak, and Ag paste, the resin containing the fluorescent substance can be made to form using various methods, such as lamination of an application, pouring, printing, and the quality of a fluorescent substance inclusion. As long as it can absorb the light from a light emitting device and fluorescence can be emitted, only what carries out proximity arrangement not only in what is covered on a light emitting device may be used.

[0022] In this way, if current is passed from the exterior to the electrode of the formed luminescence equipment, a light emitting device will emit light in the monochromatic luminescence wavelength which has a peak in about 460nm as shown in drawing 2, and the monochromatic peak wavelength which has peak wavelength in about 535nm. And from a fluorescent substance, it is excited by the light from a light emitting device, and the red system of long wavelength can mainly emit light rather than it. Therefore, RGB can make the white light in which strong luminescence is possible respectively emit light by the very easy composition whose application etc. carries out one kind of fluorescent substance on a light emitting device, and the simple method.

[0023] In addition, as long as an irregular color, color gap, etc. can be suppressed, it cannot be overemphasized that various fluorescent substances and light emitting devices can be used in addition to the above-mentioned fluorescent substance, either.

[0024]

[Effect of the Invention] The luminescence equipment of this invention can offer the light emitting diode to which the white system to which a RGB component can emit light in high brightness can emit light using the light to which the one or main colors were supplied from the multicolor light emitting device while making two colors form among the three primary colors of light using the multicolor light emitting device which can be formed with a comparatively sufficient controllability. Especially the light emitting diode of this invention is making one light emitting device emit light by supplying current for example, from two terminals. Therefore, it can consider as the white light emitting diode which contained the RGB component in high brightness without color gap or the irregular color in spite of very easy structure. Thus, the light emitting diode which contained the RGB component in high brightness can make the display of full color ** multicolor constitut by using the filter and liquid crystal of RGB. Similarly, it can also consider as the light emitting diodes for [very high] the lighting of color rendering properties etc.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] Drawing 1 shows the typical cross section of the light emitting diode of this invention.

[Drawing 2] Drawing 2 shows the emission spectrum view of the light emitting diode of this invention.

[Drawing 3] Drawing 3 shows the typical cross section of the light emitting diode for this invention and comparison.

[Drawing 4] Drawing 4 shows the emission spectrum view of light emitting diode shown for this invention and comparison.

[Description of Notations]

101 ... Fluorescent substance

102 ... Binder

103 ... Silicon on sapphire

104 ... Buffer layer

105 ... n type nitride semiconductor layer

106, 108, 110 ... Barrier layer

107 109 ... Well layer

111 ... p type clad layer

112 ... p type contact layer

113 ... Electrode

114 ... Solder

115 ... Lead electrode

116 ... Base material

117 ... Insulator layer

301 ... Resin

302 ... Fluorescent substance

303 ... Light Emitting Diode chip

304 ... Wire

315 ... Lead electrode

316 ... Case

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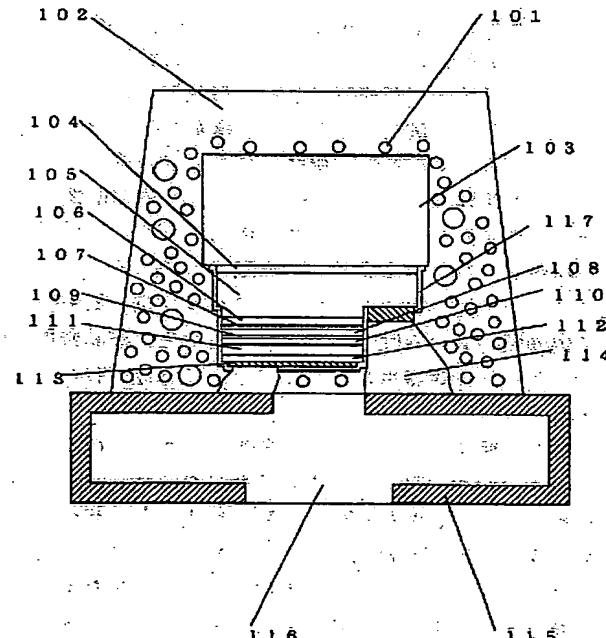
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(54) 【発明の名称】発光装置

(57) 【要約】

【課題】窒化物半導体を有する発光素子と蛍光体を有する発光ダイオードに係わり、色ズレや色むらが少なくR G B発光波長成分がそれぞれピークとして取り出すことが可能な発光ダイオードを提供する。

【解決手段】井戸層がTn濃度の異なる複数の窒化物半導体層を有する発光素子と、該発光素子からの光を受けてそれよりも長波長の蛍光を発する蛍光体とを有する発光装置である。



【特許請求の範囲】

【請求項1】 井戸層がIn濃度の異なる複数の窒化物半導体層を有する発光素子と、該発光素子からの光を受けてそれよりも長波長の蛍光を発する蛍光体とを有することを特徴とする発光装置。

【請求項2】 前記発光素子は、青色の波長域を含む単色性のピーク波長が発光可能な窒化物半導体層及び、緑色の波長域を含む単色性のピーク波長が発光可能な窒化物半導体層とを有すると共に前記蛍光体が発する蛍光は赤色の波長域を含む請求項1に記載の白色系が発光可能な発光装置。

【請求項3】 前記蛍光体は発光素子が発光する青色のピーク波長によって主として励起される請求項2に記載の発光装置。

【請求項4】 前記蛍光体は、Ceで付活された $\text{Y}_2\text{O}_3 \cdot 5/3\text{Al}_2\text{O}_3$ 、Eu及び/又はCrで付活された窒素含有CaO-Al₂O₃-SiO₂から選択される1種である請求項1乃至請求項3記載の発光装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】 本発明は窒化物半導体を有する発光素子と、発光素子からの光を吸収し波長変換して蛍光を発する蛍光体とを利用した発光装置に係わり、特に、色ズレや色むらが少なくRGB発光波長成分がそれぞれピークとして取り出すことが可能な発光装置に関するものである。

【0002】

【従来技術】 青色が高輝度に発光可能な窒化物系化合物半導体 ($\text{In}_x\text{Ga}_y\text{Al}_{1-x-y}\text{N}$ 、 $0 \leq x \leq 1$ 、 $0 \leq y \leq 1$) を利用した発光素子と、この発光素子からの青色光を吸収し黄色光が発光可能な蛍光体とを組み合わせて、これらの混色光により図3に示す如く白色系が発光可能な発光ダイオードが開発された。白色発光ダイオードは、一対のリード電極(315)と導電性ワイヤー(304)によって電気的に接続されたLEDチップ(303)が筐体(316)のキャビティ内に配置されている。キャビティには、蛍光体(302)が含まれた樹脂(301)によって、充填されている。この発光ダイオードは、発光ダイオードの小型軽量、低消費電力で信頼性の高い特性を併せ持つことから、液晶装置のバックライトや車載用の光源などとして急速に普及しつつある。

【0003】 図4に、このような発光ダイオードの発光スペクトルを示す。図4に示す如く発光ダイオードからは、単色性のピーク波長を持った発光素子からの青色光と、発光素子と比べ比較的ブロードな発光スペクトルを発するとはいえ、蛍光体からは赤みを発光する波長域は少ない黄色光との混色光が発せられる。そのため、演色性が低くなる。発光ダイオードからの白色光を着色フィルターを利用してRGB(赤色、緑色、青色)それぞれ

の波長域に分けると赤色成分が少なく、色再現性が悪くなる傾向にある。これらを防止するためには、赤色を発光する蛍光体或いは発光素子を加えることによって、解決することもできる。

【0004】 しかしながら、いずれも新たな工程が増えると共に色を調節させることが極めて難しい。したがって、場合によっては、色むらや色ズレが生じ歩留まりが低下することとなる。特に、白色発光ダイオードを液晶のバックライト光源などにする場合、発光ダイオードからの光を着色フィルターによって光の三原色であるRGB(赤色、緑色、青色)の成分に分ける。それぞれのRGBの成分を液晶によって透過率を制御することでマルチカラー表示させることができる。そのため、RGBの成分を高輝度に出せなければ、より明るく演色性の高いマルチカラー表示が難しい。

【0005】

【発明が解決しようとする課題】 したがって、本発明は比較的簡単な構成で、より色ズレや色むらの少ないRGBの発光成分が高輝度に発光可能な白色発光ダイオードを提供することにある。より高輝度低消費電力が求められる現在においては、上記発光ダイオードの構成においては十分ではなく更なる改良が求められている。

【0006】

【課題を解決するための手段】 本発明は、井戸層がIn濃度の異なる複数の窒化物半導体層を有する発光素子と、発光素子からの光を受けてそれよりも長波長の蛍光を発する蛍光体とを有する発光装置である。このような1チップ二端子の比較的簡単な構成によって、演色性の極めて高く且つ、高輝度に混色発光可能な発光ダイオードを歩留まりよく形成させることができる。

【0007】 本発明の請求項2に記載の発光装置は、発光素子が青色の波長域を含む単色性のピーク波長が発光可能な窒化物半導体層及び、緑色の波長域を含む単色性のピーク波長が発光可能な窒化物半導体層とを有すると共に蛍光体が発する蛍光は赤色の波長域を含む発光装置である。これによって、比較的簡単な構成で、RGBを高輝度に発光可能な白色発光ダイオードを形成させることができる。

【0008】 本発明の請求項3に記載の発光装置は、蛍光体が発光素子からの青色単色性のピーク波長によって主として励起される発光装置である。これによって、信頼性高く高輝度に発光可能な蛍光体を利用することができる。

【0009】 本発明の請求項4に記載の発光装置は、蛍光体がCeで付活された $\text{Y}_2\text{O}_3 \cdot 5/3\text{Al}_2\text{O}_3$ 、Eu及び/又はCrで付活された窒素含有CaO-Al₂O₃-SiO₂から選択される1種である。これにより簡便で高輝度に信頼性の高い混色発光可能な発光装置とすることができる。

【0010】

【発明の実施の形態】本発明者は青色及び緑色が発光可能な窒化物半導体発光素子と、赤色が発光可能な蛍光体とを組み合わせることによって、比較的簡単な構成によりRGBの成分をバランスよく高輝度に取り出すことができる白色発光ダイオードとすることを見出したものである。

【0011】即ち、窒化物半導体を利用した発光素子は、Inの組成比を増減させることで紫外から赤色まで発光可能な発光素子を形成させることができるとされている。これは、活性層のIn含有量を増やすことにより、その組成比に応じて長波長の発光を得られる傾向があるためである。しかし、Inを多く含んだ窒化物半導体は、高温になると分解されやすい。また、結晶性の良好なIn量の多い窒化物半導体層を形成させることは極めて難しい。そのため、青色、緑色や黄色が発光可能な発光素子は、現在のところ比較的制御性よく高輝度に発光可能なものが形成できるが、赤色成分を含む単色性のピーク波長が発光可能な発光素子が形成しがたい理由の一つである。

【0012】したがって、本発明は比較的制御性よく青色成分及び緑色成分が発光可能な窒化物半導体を多重量子井戸構造を利用した発光素子として形成させる。つまり、複数の井戸層の混晶比が異なっており、各井戸層から異なる色成分、例えば青色成分及び緑色成分の発光をさせ合成光を取り出させる。他方、残りの赤色成分を発光素子から放出された電磁波例えは青色の可視光によって励起され、それよりも長波長の可視光に変換する蛍光体を利用して白色発光ダイオードを形成せるものである。

【0013】以下、本発明の発光装置を図1に示し、具体的な構成について詳述するがこれのみに限られないことは言うまでもない。本発明の半導体は、MOCVD法を利用し、原料ガスとしてTMG(トリメチルガリウム)ガス、TMA(トリメチルアルミニウム)ガス、TMI(トリメチルインジウム)ガス、アンモニアガス、不純物ガスとしてSiH₄(シラン)、Cp₂Mg(シクロペンタジエニルマグネシウム)及びキャリアガスとして水素ガスを種々所望に応じて流し、所望の半導体膜を成膜させることができる。

【0014】より具体的には、サファイア基板(103)上に、低温で成膜させたGaNからなるバッファ層(104)、n型不純物濃度が少ない或いはドープされていないn型GaN層、n型電極が形成されるSi含有のGaNからなるn型コンタクト層、n型不純物濃度が少ない或いはドープされていないn型GaN層(これら三つのn型窒化物半導体層を模式的に105としている)、Si含有のAlGaN及びSi含有のGaNを複数積層させ好適に用いられたn型クラッド層(不示図)、量子井戸構造とされる膜厚の障壁層としてのGaN(106)(108)(110)/井戸層としてのI

nGaN(107)(109)を複数組積層させた発光層、MgがドープされたGaN/MgがドープされたGaInNを複数組積層させたp型クラッド層(111)、MgがドープされたGaNからなるp型コンタクト層(112)を積層させてなる。こうして積層された半導体ウェハのn型及びp型コンタクト層をエッチングにより露出させると共にそれぞれn型及びp型用の電極(113)をスパッタリング法などにより半導体ウェハ上に形成させる。各電極露出面以外をSiO₂の絶縁部材で被覆する。その後、半導体ウェハを各発光素子の大きさにダイサー/スクリーバーを利用して切断することにより、それぞれを発光素子とすることができます。

【0015】本発明で特徴的なことは、発光層として働くGaN(106)(108)/InGaN(107)(109)/GaN(106)(110)が複数組有り、In組成比が異なる井戸層(107)(109)が少なくとも2種類ある。特に、その内少なくとも一つが420nmから490nmに単色性のピーク波長を持つ青色光が発光可能にIn組成比が好適に選択されている。他方、残りの井戸層の内少なくとも一つが495nmから555nmに単色性のピーク波長を持つ緑色光が発光可能にIn組成比が好適に選択されている。そのため、発光素子から放出される光は例えは青色と緑色の混色光であるシアンが観測されることとなる。なお、より短波長を発光する発光層の方が結晶性よく形成できる傾向にあるため、サファイア基板、スピネル基板、窒化ガリウム基板やSiC基板上から窒化物半導体を形成させる場合、青色を発光する井戸層を緑色を発光する井戸層よりも基板側に配置させることが好みしい。また、各色の発光強度を調節させるためには井戸層の積層数を増減させてやれば比較的簡単に調節させることができる。

【0016】次に、本発明では発光素子から放出された光によって、励起されそれよりも長波長の赤色系が発光可能な蛍光体を用いる。蛍光体は、励起波長よりも長波長の蛍光を発する方が効率が高い。また、蛍光体には無機蛍光体と有機蛍光体があるが有機蛍光体は、励起波長と発光波長とが比較的近づけることができ、且つ効率よく発光可能なものとすることができる。したがって、発光素子からの青色光を受け赤色が発光可能な蛍光染料や有機蛍光顔料だけでなく、緑色光を吸収して赤色光が発光可能な蛍光染料や有機蛍光顔料を用いることができる。これによって、色味を調整させやすくすることができる。他方、無機蛍光体は、より発光素子に近接して設けても長時間にわたって信頼性よく発光可能な傾向にある。

【0017】このような蛍光体(101)として、Ceで付活されたY₂O₃·5/3Al₂O₃、Eu及び/又はCrで付活された窒素含有CaO-Al₂O₃-SiO₂が挙げられる。他にも、Mg₆Li₆Sb₂O₁₃:Mn、Mg₂TiO₄:Mn、Y₂O₃:Eu、Y₂O₂S:Eu、

3. $5\text{MgO} \cdot \text{MgF}_2 \cdot \text{GeO}_2 \cdot \text{Mn}$ やペリレン系誘導体などを好適に挙げることができる。

【0018】例えば、Eu及び/又はCrで付活された窒素含有CaO-Al₂O₃-SiO₂蛍光体は、酸化アルミニウム、酸化イットリウム、窒化珪素及び酸化カルシウムなどの原料に希土類原料を所定比に混合した粉末を窒素雰囲気下において1300℃から1900℃(より好ましくは1500℃から1750℃)において溶融し成形させる。成形品をボールミルして洗浄、分離、乾燥、最後に篩を通して蛍光体を形成させることができ。これにより450nmにピークをもった励起スペクトルと約450nmにピークがある青色光により赤色発光が発光可能なEu及び/又はCrで付活されたCa-Al-Si-O-N系オキシナイトライド蛍光硝子とすることができる。

【0019】なお、Eu及び/又はCrで付活されたCa-Al-Si-O-N系オキシナイトライド蛍光硝子の窒素含有量を増減することによって発光スペクトルのピークを575nmから690nmに連続的にシフトすることができる。同様に、励起スペクトルも連続的にシフトさせることができる。そのため、Mg、Znなどの不純物がドープされたGaNやInGaNを発光層に含む窒化ガリウム系化合物半導体からの光を、約580nmの蛍光体の光の合成光により白色系を発光させることができる。特に、約490nmの光が高輝度に発光可能なInGaNを発光層に含む窒化ガリウム系化合物半導体からなる発光素子との組合せに理想的に発光を得ることもできる。

【0020】同様に、Y₂O₂S:Euであれば、Y₂O₃とEu₂O₃を塩酸で溶解後、しづう酸塩として共沈させる。この沈殿物を空気中で800から1000℃で招請して酸化物とする。さらに硫黄と炭酸ソーダ及びフランクスを混合しアルミナの坩堝に入れ1000℃から1200℃の空気中で2時間から3時間焼成して焼成品を得る。焼成品を粉碎、洗浄、分離乾燥して最後に篩に通すことでY₂O₂S:Euの蛍光体を得る。この蛍光体は、発光素子からの青色光を効率よく吸収して赤色系の蛍光を発することができる。上述の蛍光体は1種類で用いても良いし、2種類上を混合させて用いることもできる。

【0021】エポキシ樹脂やシリコーン樹脂或いは低融点硝子などのバインダー(102)中に、この蛍光体(101)を混合しスラリーとする。上述した青色及び緑色がそれぞれ発光可能な活性層を持った多重量子井戸構造の発光素子に蛍光体含有のスラリーを塗布、硬化させて発光装置を形成させる。或いは、ダイポンド樹脂として併用することもできる。より具体的には、回路基板上に発光素子を配置させて金線などの導電性ワイヤーやAgペーストなどの導電性ペースト(114)を利用して電気的に接続させた後、蛍光体が入った樹脂を塗布、注入、印刷、蛍光体含有物質の張り合わせなど種々の方

法を利用して形成させることができる。発光素子からの光を吸収して蛍光を発することができる限り、発光素子上に被覆するものだけでなく、近接配置させるだけのものでも良い。

【0022】こうして形成された発光装置の電極に外部から電流を流すと図2に示す如く約460nmにピークがある単色性の発光波長と、約535nmにピーク波長がある単色性のピーク波長を発光素子が発光する。そして、蛍光体からは発光素子からの光によって励起され、それよりも長波長の赤色系が主として発光することができる。そのため、発光素子上に1種類の蛍光体を塗布等する極めて簡単な構成、且つ簡便な方法で、RGBが、それぞれ強発光可能な白色光を発光させることができる。

【0023】なお、色むらや色ズレなどを抑制できる限り、上記蛍光体に加えて種々の蛍光体や発光素子を利用できることもいうまでもない。

【0024】

【発明の効果】本発明の発光装置は、比較的制御性よく形成できる多色発光素子を利用して、光の三原色のうち、2色を形成させると共に、残りの1色を多色発光素子から供給された光を利用してRGB成分が高輝度に発光可能な白色系が発光可能な発光ダイオードを提供できるものである。特に、本発明の発光ダイオードは、例えば2端子から電流を供給することで1つの発光素子を発光させているにすぎない。そのため、極めて簡単な構造にも係わらず、色ズレや色むらなく高輝度にRGB成分を含んだ白色発光ダイオードとすることができる。このように、RGB成分を高輝度に含んだ発光ダイオードは、RGBのフィルタ及び液晶を利用することによって、フルカラーやマルチカラーの表示装置を構成させることができる。同様に、演色性の極めて高い照明用などの発光ダイオードとすることもできる。

【図面の簡単な説明】

【図1】 図1は、本発明の発光ダイオードの模式的断面図を示す。

【図2】 図2は、本発明の発光ダイオードの発光スペクトル図を示す。

【図3】 図3は、本発明と比較のための発光ダイオードの模式的断面図を示す。

【図4】 図4は、本発明と比較のために示す発光ダイオードの発光スペクトル図を示す。

【符号の説明】

101・・・蛍光体

102・・・バインダー

103・・・サファイア基板

104・・・バッファ層

105・・・n型窒化物半導体層

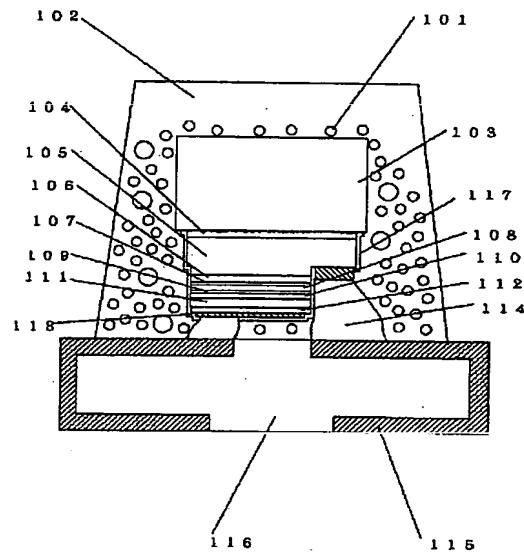
106、108、110・・・障壁層

107、109・・・井戸層

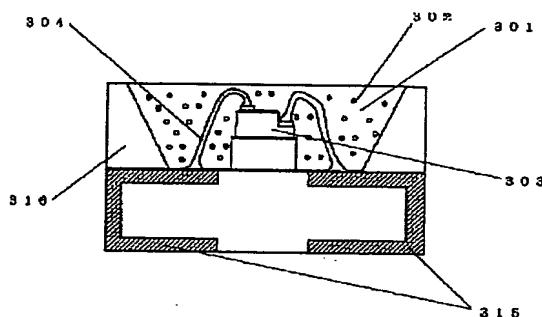
7
 111 … p型クラッド層
 112 … p型コンタクト層
 113 … 電極
 114 … 半田
 115 … リード電極
 116 … 支持体
 117 … 絶縁膜

301 … 樹脂
 302 … 融光体
 303 … LEDチップ
 304 … ワイヤー
 315 … リード電極
 316 … 管体

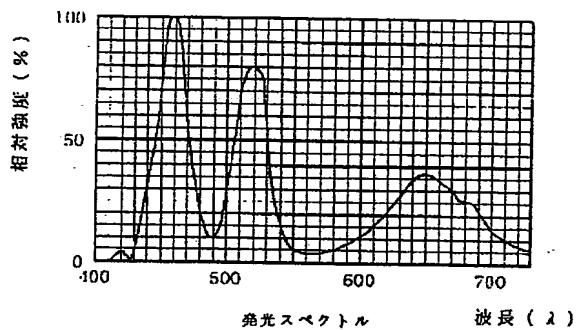
【図1】



【図3】



【図2】



【図4】

